Avionics Architecture for Exploration Project
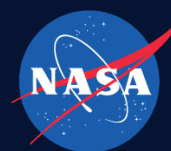
Advanced Exploration Systems Program | Human Exploration And Operations Mission Directorate (HEOMD)

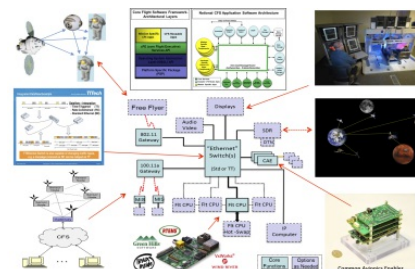
Avionics Architecture for Exploration

ABSTRACT

The goal of the AES Avionics Architectures for Exploration (AAE) project is to develop a reference architecture that is based on standards and that can be scaled and customized. The architecture will contain basic core elements and functionality needed for any spacecraft. The goal for specific mission implementation is that the avionics will be 80% core AAE elements and 20% unique.

The AAE project will also focus on the affordability and maintainability of the avionics systems. The project will take into account design, development, test and evaluation (DDT&E) costs, maintenance costs, upgrade flexibility, size, weight, and power (SWaP).

The following architecture guidelines will be followed:

- Minimize SWaP for Avionics in Flight Vehicle
  - Use wireless where possible
  - Minimize wire weight
  - Use low/no power sensors
  - Pick a topology that keeps the processors close to what they control
- Minimize Cost
  - Use existing capabilities to avoid near-term DDT&E
  - Allow for growth using new technology to avoid future DDT&E
  - Allow for infusion of new technology to reduce sustaining costs
- Minimize Risk (multi-faceted)
  - Use proven technology for critical functions
  - Use existing capabilities to minimize schedule risk
- NASA should develop and own the Reference Architecture
  - Develop a reference implementation of the architecture that can be provided to industry as a basis for standards

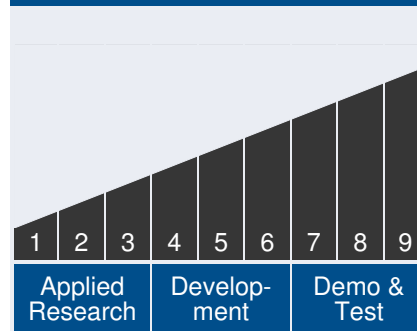(Note: this project started as Common Avionics but the name

Table of Contents

Technology Maturity

1	2	3	4	5	6	7	8	9
Applied Research			Develop-ment			Demo & Test		

Management Team

Program Director:
- Jason Crusan

Program Executive:
- Richard Mcginnis

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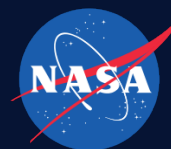
was changed. All data pertaining to the Common Avionics project has been incorporated into this project.)

The results of this project will be incorporated into the AES Avionics and Software project.

ANTICIPATED BENEFITS

To NASA funded missions:

Quicker systems development and reduced costs.

To NASA unfunded & planned missions:

Quicker systems development and reduced costs.

To the commercial space industry:

The architecture will give a common set of interfaces and functions for industry to build to. If other government agencies adopt this architecture, they should benefit from quicker development and reduced costs.

To the nation:

Quicker system development and reduced costs for human space exploration.

DETAILED DESCRIPTION

The AAE project team will develop a system-level environment and architecture that will accommodate equipment from multiple vendors in order to benchmark performance for missions beyond low Earth orbit (LEO). This will allow NASA to take advantage of strides being made by industry to drive our development and sustaining costs down. The project team will also evaluate emerging technologies in industry and academia to ensure that other potentially beneficial concepts are not overlooked.

The reference architecture will be developed by dividing it into three core areas: Command and Data Handling (C&DH), Communications, and Human Interfaces. The hardware selected for these core areas will typically be high TRL and currently

Management Team (cont.)

Project Manager:
- James Ratliff

Technology Areas

Primary Technology Area:
Communications, Navigation, and Orbital Debris Tracking and Characterization Systems (TA 5)
└ Position, Navigation, and Timing (TA 5.4)
  └ Onboard Auto Navigation and Maneuver (TA 5.4.2)
    └ Fault-Resistant, High Performance Navigation Architectures (TA 5.4.2.2)

Secondary Technology Area:
Robotics and Autonomous Systems (TA 4)
└ Systems Engineering (TA 4.7)
  └ Robot Software (TA 4.7.4)
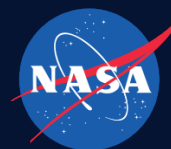   └ Robotic Architecture and Frameworks (TA 4.7.4.1)

Robotics and Autonomous Systems (TA 4)
└ Human-System Interaction (TA 4.4)
  └ Distributed Collaboration and Coordination (TA 4.4.5)
    └ Interaction Architecture (TA 4.4.5.1)

available. The hardware must also have lineage that gives the team confidence that a radiation tolerant version that can survive the environment beyond Earth orbit will be available within a reasonable time.

The C&DH Team will focus on the areas of single board computers, network architecture and hardware, instrumentation systems, and hardware/network standards. They will address radiation tolerance issues with higher performance processors that are required to support the demands of human exploration. Various network technologies will be investigated for critical and non-critical applications.

The Communications Team will focus on developing a communications architecture that will operate over multiple mission phases and across various users, including international partners. They will take into account communications amongst several vehicles, EVA, and the ground. The communications team will consider systems that support multiple formats, reconfigurability, adaptive power control, and other cognitive capabilities as well as utilize wireless technology where possible to reduce vehicle weight (less wires). The system will have to address the high data rate demands of human exploration. The communications team will evaluate existing communications hardware from industry and other centers. They will also consider existing agency and international standards.

The Human Interface Team will address the great challenge of providing displays, audio systems, video systems, and controls that will reliably function in the environment beyond low Earth orbit. They will evaluate new display technologies (such as OLEDs) and Graphics Processing Unit options (including a software GPU). Off-the-shelf video and audio systems will be evaluated for performance, integration within the architecture, and environmental concerns.

These three teams will work together to produce a reliable and flexible reference avionics architecture that will be demonstrated in the Integrated Power, Avionics, and Software (iPAS)

Technology Areas *(cont.)*

Human Exploration Destination Systems (TA 7)
└ Cross-Cutting Systems (TA 7.6)

Nanotechnology (TA 10)
└ Sensors, Electronics, and Devices (TA 10.4)
   └ Nanoelectronics (TA 10.4.2)
      └ Advanced Architectures (e.g., Spintronics) (TA 10.4.2.4)

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laboratory at JSC. The iPAS laboratory will provide an excellent place to infuse and validate new architectural components of the avionics architecture. The lab can support multiple vehicles of various avionics implementations communicating together in a mission scenario. Three integrated tests are planned throughout FY14 as the avionics architecture evolves.

U.S. WORK LOCATIONS AND KEY PARTNERS
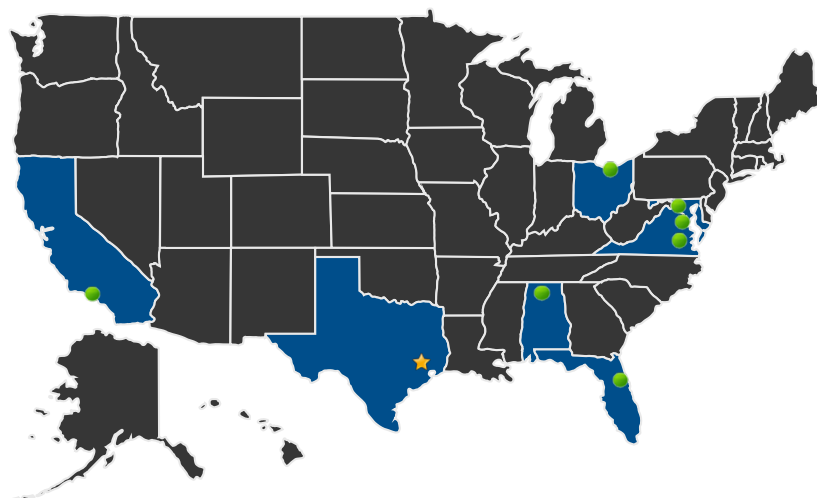
■ U.S. States With Work

★ **Lead Center:** Johnson Space Center

● **Supporting Centers:**
- Glenn Research Center
- Goddard Space Flight Center
- Jet Propulsion Laboratory
- Kennedy Space Center
- Langley Research Center
- Marshall Space Flight Center
- NASA Headquarters

Technology Areas *(cont.)*

Modeling, Simulation, Information Technology and Processing (TA 11)
└ Computing (TA 11.1)
  └ Flight Computing (TA 11.1.1)
    └ Radiation-Hardened General Purpose Flight Processor (TA 11.1.1.1)
    └ High Performance Flight Software (TA 11.1.1.3)
    └ Low Power Embedded Computer (TA 11.1.1.4)
└ Modeling (TA 11.2)
  └ Frameworks, Languages, Tools, and Standards (TA 11.2.5)
    └ Profiles for Spacecraft, Space Robotics, and Space Habitats (TA 11.2.5.2)
    └ Executable Models (TA 11.2.5.4)
└ Simulation (TA 11.3)
  └ Simulation-Based Training and Decision Support Systems (TA 11.3.4)
    └ Digital-Human-in-the-Loop Simulation System (TA 11.3.4.3)
└ Information Processing (TA 11.4)
  └ Science, Engineering, and Mission Data Lifecycle (TA 11.4.1)
    └ Reference Information System Architecture Frameworks (TA 11.4.1.1)
    └ Distributed Information

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Technology Areas *(cont.)*

Ground and Launch Systems (TA 13)
└ Operational Life-Cycle (TA 13.1)
   └ Automated Alignment, Coupling, Assembly, and Transportation Systems (TA 13.1.2)
      └ Self-Verifying Coupler Interfaces (TA 13.1.2.7)
   └ Autonomous Command and Control for Integrated Vehicle and Ground Systems (TA 13.1.3)
      └ Multi-Mission Control Centers (TA 13.1.3.4)
      └ Automated Fault Detection and Isolation Systems (TA 13.1.3.5)
      └ Integrated Ground and Flight Vehicle Health Management (IVHM) (TA 13.1.3.12)
      └ Advanced, Deployable Sensor Networks for Spacecraft, Launch Vehicle, and Pad Monitoring (TA 13.1.3.13)
└ Reliability and Maintainability (TA 13.3)
   └ Launch Infrastructure (TA 13.3.1)
      └ Runway Surface Movement Detection System (TA 13.3.1.12)
   └ Communications, Networking, Timing, and Telemetry (TA 13.3.7)
      └ State Aware Monitor and Control (TA 13.3.7.1)

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Technology Areas (cont.)

Aeronautics (TA 15)
└ Safe, Efficient, Growth in
  Global Aviation (TA 15.1)
  └ System-Wide Safety,
    Predictability, and
    Reliability through Full
    NextGen Functionality (TA
    15.1.2)
    └ Optimize Air/Ground
      Functional
      Allocations (TA
      15.1.2.3)

DETAILS FOR TECHNOLOGY 1

Technology Title

Avionics Architecture for Exploration

Technology Description

This technology is categorized as an architecture for computers

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accommodate equipment from multiple vendors in order to benchmark performance for missions
beyond low Earth orbit (LEO). This will allow NASA to take advantage of strides being made by
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Capabilities Provided

Th AAE project will develop a common avionics architecture for HEOMD systems that can evolve as mission needs and technology change. This is expected to reduce the cost of systems development and operations.

Potential Applications

Initially, this will be part of common core avionics services for future human exploration. However, the architecture is generic and can be used by any mission desiring it. This could include science missions or missions by other agencies.